in preventing enzootic marasmus in sheep. Fractionation of this filtrate and tests of the elements in the effective fraction resulted in Underwood and Filmer[2] announcing in 1935 that cobalt was the potent element in effective limonite. This was the first evidence that cobalt was an essential element.

At that time, Grimmett and Shorland[3] held that iron *per se* was necessary for the prevention of "bush sickness" in New Zealand, but that cobalt and other elements might have a stimulating effect. Denham[4] has reviewed the present status of the investigation of cobalt deficiency in New Zealand. Ferric ammonium citrate and iron ores effective in preventing bush sickness or "skinnies" owed their efficacy to their cobalt content. Other ores that were ineffective did not have equivalent cobalt contents. Cobalt alone has been effective in the more recent experiments.

In Florida, on certain soil types, ferric ammonium citrate or a commercial red oxide of iron and copper sulfate have been effective in overcoming a nutritional anemia in cattle known as "salt sick." On other soils, this treatment has been ineffective in inducing and maintaining normal function due to an overlapping of cobalt deficiency. In controlled feeding experiments with calves on a ration of Natal grass (*Tricholena rosea*) hay, shelled corn and dried skim milk, a malnutrition has been produced that is corrected by cobalt supplement, and apparently is aggravated by the use of ferric ammonium citrate and copper sulfate. None of these feeds showed cobalt to be present upon spectrographic examination.

Affected animals show a long rough hair coat, scaliness of the skin, listlessness, retarded development of sexual characteristics, gauntness due to loss of appetite and muscular atrophy. The erythrocyte count may be above average, and the hemoglobin concentration equal to or above that in animals receiving cobalt and making normal growth. Volume and color indices show that the condition is a microcytic hypochromic anemia. The spleen is shriveled and fibrous and the heart of normal size but usually flabby.

Examples of growth rates of Jersey calves are shown in Fig. 1. Animal No. E-79, receiving 5 mgs cobalt per day, made uniform gains until he weighed over 550 pounds. Irregularities in his growth curve and that of E-74 at the higher weights may be attributed to a marginal cobalt intake or to an additional undetermined deficiency. That cobalt intake may have been marginal is shown by the increased growth of E-86 when the cobalt intake was increased. Animal No. E-86, receiving cobalt, weighed 85 pounds more than E-85 on the basal ration at 14 months of age, and

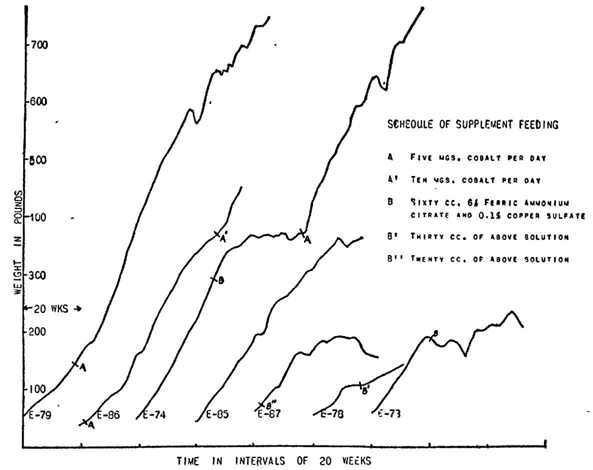

FIG. 1. Growth curves of calves showing the effect of cobalt, and iron and copper supplements, with a ration of Natal grass hay, shelled corn and dried skim milk, the hay and corn being produced on deficient land.

the differences in physical appearance were even more striking. The retarded growth due to the use of ferric ammonium citrate and copper sulfate is shown in the curves for E-74, E-87, E-78 and E-73. No calf has been raised to a weight of over 450 pounds on this ration of Natal grass hay, shelled corn and dried skim milk without the use of a cobalt supplement.

Animal No. E-79, when slaughtered, appeared to be normal, including microscopic examination of the heart, liver and spleen, the organs most affected.

The indispensability of any element in nutrition can be determined only under conditions in which the addition of the element in question is required for a continuance of normal physiological function. These conditions may be encountered naturally or they may be produced artificially. The requirement of animals for certain minerals is so minimal in quantity, and their determination so difficult, that such minerals have not been considered as essential because rations have not been prepared sufficiently free of them to cause a failure of normal functions. Cobalt has been one of these elements.

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MAGNESIUM SULFATE—AN UNSATISFACTORY SUBSTITUTE FOR ARSENICALS IN GRASSHOPPER BAITS

WIDE publicity was given to a short note by Hubert W. Frings and Mable S. Frings which was published in SCIENCE[1] in which a formula with from 20 to 25 per cent. magnesium sulfate (Epsom salts) was recommended as being as effective as 5 per cent. arsenic in grasshopper bait. The communication was printed

[2] E. J. Underwood and J. F. Filmer, *Australian Vet. Jour.*, 11: 89–92, 1935.
[3] R. E. R. Grimmett and F. B. Shorland, *New Zealand Jour. Agr.*, 50: 367, 1935.
[4] H. G. Denham, SCIENCE, 85: 382–383, 1937.

[1] 85: 2209, 428, April 30, 1937.

under "Discussion" and the authors stated that "since there were neither time nor facilities to make complete tests, the results are only preliminary."

The substance of this article was published by Science Service and was widely copied by newspapers. As a result, many farmers throughout the central west used Epsom salts in grasshopper baits, but in every case so far reported unsatisfactory results were obtained. The publicity brought a heavy correspondence, and insecticide dealers featured magnesium sulfate in their lists, giving special quotations on ton lots.

Three small and one large field tests of Epsom salts bait in comparison with bait made with standard poisons have just been completed by the writer with the uniform results that Epsom salts did not give satisfactory results. Since this matter is of wide public interest, a brief account of these tests has been prepared for publication.

EPSOM SALTS GRASSHOPPER BAIT TESTS

The Epsom salts bait was tested in so-called single and double strength mixtures in infested alfalfa fields and gardens in comparison with the regular mixtures made with sodium arsenite. The exact mixtures used were as follows:

(1) EPSOM SALTS BAIT

(a) Frings' formula:

Bran	60 to 65 per cent.
Molasses	15 per cent.
Epsom salts	20 to 25 per cent.
Water to moisten	

(b) As used in tests, single strength:

Bran 3 lbs., sawdust 3 lbs. =	6 lbs.
Molasses, black strap, 1 pt. =	$1\frac{1}{2}$ "
Epsom salts	2 "
Water	1 gal.

(2) DOUBLE STRENGTH EPSOM SALTS

Bran $2\frac{1}{2}$ lbs., sawdust $2\frac{1}{2}$ lbs. =	5 lbs.
Epsom salts	4 "
Molasses	1 lb.
Amyl acetate	$\frac{1}{2}$ oz.
Water to moisten, about	3 qts.

(3) SODIUM ARSENITE BAIT

(a) 1 quart of Pierson-Ferguson "hopper poison" (being a mixture of sodium arsenite, amyl acetate and molasses) to 3 lbs. of bran, 3 lbs. of sawdust and 1 gal. of water.

(b) 1 pint of sodium arsenite (4 lbs. material), 1 qt. black strap molasses, 3 oz. amyl acetate (banana oil), 10 lbs. of bran, 10 lbs. of sawdust and 3 gals. of water.

These baits were mixed in clean tubs the evening before sowing. The Epsom salts were purchased at a local drug store at the rate of twenty-nine cents for five pounds. The bait was sowed thinly or at the rate of about seven to ten pounds to the acre at about 6 o'clock in the morning. Two hours after sowing, between fifty and one hundred grasshoppers, about three fourths of which were nymphs, were swept from the area where the bait was sown and they were confined in large screen cages over alfalfa plants to await counts of the live and dead hoppers at twenty-four and forty-eight hours. Another set of sweepings was made four to six hours after sowing and caged in the same way. This constitutes the most widely accepted manner of testing grasshopper baits. As a check, sweepings were made for a similar collection of hoppers at the two- and four-hour intervals where bait was not sown. These were caged in the same way and the proportionate number of hoppers dying naturally or from injuries was subtracted from the number found dead in the poisoned lots in figuring the per cent. kill. The counts with the per cent. kill are given in Table 1.

TABLE 1

RESULTS OF TESTS WITH GRASSHOPPER BAITS MADE WITH EPSOM SALTS (SINGLE AND DOUBLE STRENGTH) IN COMPARISON WITH STANDARD BAITS

Date	Formula used	Place sown	Cage counts at end of 48 hours from collections of hoppers collected				Net per cent. kill	
			Two hours after sowing		Four to six hours after sowing		Two hour coll.	Four to six hour coll.
			live	dead	live	dead		
June 21, 1937	Epsom salts (1b)	Border of alfalfa field	74	4	86	5	0	0
June 21, 1937	Sodium arsenite (3a)	Same	46	61	31	11	54	20.5
June 21, 1937	Check cage	Another alfalfa field	70	5	70	5	...	...
June 27, 1937	Epsom salts dble. strength (2)	Alfalfa field	49	6	116	9	0	0
June 27, 1937	Sodium arsenite (3a)	" "	60	15	61	9	10.4	3.1
June 27, 1937	Check	" "	71	9	45	5	...	...
June 30, 1937	Epsom salts (2)	" "	50	2	75	5	0	0
June 30, 1937	Sodium arsenite (3a)	" "	75	6	25	110	2.6	80
June 30, 1937	Check	" "	75	4	140	11	...	...
July 14, 1937	20% Epsom salts 5% $CaCl_2$	Atchison corn field	42	2	68	10	0	4.2
July 14, 1937	Paris green, standard bait	" " "	24	6	22	34	11.1	56.9
July 14, 1937	Check	" " "	21	2	...	...	...	...

Hungry grasshoppers were exposed to small quantities of these baits in small cages against a check made omitting the poison, and they fed on all of them. This would indicate that both the single and double strength Epsom salts baits were acceptable to grasshoppers. They died in the Epsom salts cages somewhat faster than in the check cages of unpoisoned bran mash, but that is regarded as of little significance.

Observations on the caged hoppers from the experimental plots after the forty-eight-hour period when the last counts were made showed that there was no larger death loss in the Epsom salts cages than in the check cages. In other words, Epsom salts did not kill the hoppers after forty-eight hours.

Cabbage, sweet corn, tomatoes, string beans and squash foliage were sprayed with a nearly saturated solution of Epsom salts (2⅜ oz. in 4 oz. or 100 cc of water at 70° F.) and no injury was done to the plants. Cabbage loopers and cabbage worms on the cabbage were not killed by the spray.

The three series of sowings indicate that Epsom salts used in bran mixture grasshopper bait was uniformly unsuccessful. Even double the recommended amount of Epsom salts in bait mixtures was ineffective. In these tests, Epsom salts was without value for destroying grasshoppers.

A field test of Epsom salts plus calcium chloride against the standard Paris green bait was made in a heavily infested field of corn near Atchison, Kansas, on July 14 in company with Dr. Harry Miller, of The Chemical Foundation of Kansas. A sowing of 120 pounds of bait according to Dr. Miller's modification of the Frings' formula of 20 per cent. magnesium sulfate (Dow Chemical Company) and 5 per cent. crude calcium chloride against one hundred pounds of Paris green bait gave a net kill of 4.2 per cent. at forty-eight hours against 56.9 per cent. for Paris green.

A survey of the literature offers little evidence that magnesium sulfate has any value as an insecticide whatsoever. There is not a single really impressive field control demonstration recorded. The small test by Hawkins against the wheat wire worm mentioned by the Frings' was apparently not regarded as significant by him, for he drew no practical conclusions from it.

The action of magnesium sulfate on the lower animals is primarily anesthetic. There was no cathartic action observed on the grasshoppers.

It is unfortunate that the extensive publicity on the supposed value of Epsom salts resulted in widespread use of a material that appears to be ineffective for the purpose. It is serious, because many persons may have their faith in the standard bait method weakened. At the present time, only sodium arsenite, white arsenic, gray or crude arsenic, Paris green, sodium fluoride and sodium fluosilicate in baits give anything approaching satisfactory control of hoppers. For the present at least, Epsom salts can not be recommended as a satisfactory control for any insect.

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FITNESS, SULFANILAMIDE AND PNEUMOCOCCUS INFECTION IN THE RABBIT

THIS is a preliminary report of an investigation of the extent to which the effectiveness of sulfanilamide in experimental pneumococcus infection, in the rabbit, may be determined by factors reflected in the fitness rating.

The fitness rating is an index of condition and of capacity for resistance. Rabbits with high fitness ratings accomplish the removal of intravenously injected pneumococci from the blood more rapidly than rabbits with ratings appreciably lower.[1]

Transient improvement in fitness rating has been obtained in 70 per cent. of sixty-three rabbits given extract of adrenal cortex, extract of liver, vitamin B_1 or vitamin C. Intravenous injection of the latter substance, ten minutes before intravenous infection with type I pneumococcus, has been followed by substantial increase in capacity for the removal of pneumococci from the blood. Seven out of eleven rabbits, so treated, were enabled to reach a negative blood culture in one-half hour, as compared with a proportion of three out of twelve in a series of comparable controls.

The percentage recovery in a series of forty-four rabbits infected intradermally with a virulent strain of type I pneumococcus was as follows: 33 per cent. for six untreated, control rabbits with fitness ratings above the critical level of 0.6; 86 per cent. for seven rabbits of equivalent rating, given sulfanilamide at the beginning of the second and sixth hours of infection and at six-hour intervals thereafter; 100 per cent. in five equivalent rabbits given vitamin C in addition to sulfanilamide at the times stated; 0 per cent. for seven untreated, control rabbits with fitness ratings between 0.6 and 0.4; 25 per cent. for eight rabbits comparably low-grade but given sulfanilamide; 71 per cent. for seven similar rabbits given sulfanilamide plus vitamin C; 100 per cent. for four, only, equivalent rabbits given sulfanilamide plus either liver extract or vitamin B_1.

The contribution of the sulfanilamide was apparent in the increase in percentage survival in the higher

[1] A. Locke, *Jour. Infect. Dis.*, 60: 106, 1937.